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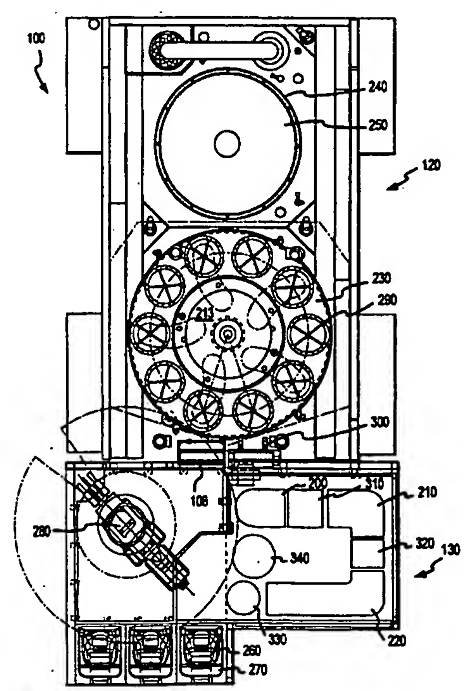

(57) Abstract: An improved fluid track for transporting a workpiece is disclosed. The fluid track includes a base having apertures formed therein and rails to guide the workpiece to a desired location. The track is designed such that fluid that flows through the apertures suspends the workpiece above the base of the track. The workpiece is urged in a desired or predetermined direction by applying a fluid (*e.g.*, through a nozzle) to a surface of the workpiece.

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APPARATUS FOR MOVING A WORKPIECE

FIELD OF THE INVENTION

The present invention generally relates to apparatus for moving a workpiece. More particularly, the invention relates to a track that uses a fluid to suspend and guide a workpiece from one location to another.

BACKGROUND OF THE INVENTION

Fluid or water tracks may be used for a variety of applications to transfer various workpieces from one location to another. For example, water tracks may be employed on semiconductor wafer polishing machines (*e.g.*, chemical mechanical polishing, "CMP" machines) to transport a wafer from one processing station to another within the tool or between process stations on separate tools.

A typical CMP machine includes at least one polishing station and load and unload stations. The CMP machine may also include additional post-polishing stations to, for example, clean, rinse, and dry the wafer.

Water tracks on CMP machines are typically employed to transport wafers from an area proximate a post-polish holding location or index table to a subsequent process station. In particular, water tracks may be used to transport wafers to post-polish scrubbing and rinsing stations. Using water tracks to transport wafers is advantageous because the wafers are kept wet during the transportation process. Keeping the wafers wet during transfer to post-polishing processes is advantageous because it prevents debris such as slurry used in the polishing process and other particles from adhering to the wafer surface as the surface drys. In other words, the track allows the wafers to be kept wet until the wafer is exposed to cleaning and rinsing processes, which are configured to remove debris from surfaces of the wafers. In addition, water tracks may be used to replace robots or other machinery used to transport wafers from one location to another. Reducing machine handling of wafers tends to reduce damage or breakage of the wafers that results from mechanical transportation of the wafers.

As discussed in greater detail below, prior-art water tracks require a substantial amount of water (*e.g.*, about 21 liters per minute over a surface area of about 2900 cm^2 or about 0.007 $l/cm^2/min.$) to keep the wafer afloat and to cause the wafer to move downstream. Often, the water tracks require the upper limit of water pressure a facility may supply for the tracks to work as desired. As a result, perturbations in the facility water supply, which may be caused by fluctuations external to or within the facility water supply system, may deleteriously affect the

water track performance. In addition, water consumption of the track affects the operating cost of the track, which in turn affects wafer processing costs; *i.e.*, the more water consumed by the track, the more expensive the wafer becomes. Accordingly, improved water tracks preferably require less than about 0.007 $l/cm^2/min.$ of water to move a wafer over a predetermined surface area.

A typical water track includes a channel or conduit including a base and sidewalls configured to retain water; rails that extend upward from the base which guide the wafer as it travels along the track; and water supply devices such as apertures formed within the base that supply water to the track. The apertures supply a stream of flowing water within the conduit that causes the wafer to move in the direction of the water flow.

The conduit base generally includes recesses and/or protrusions that run along the length of the track. Although the recesses and/or protrusions may assist keeping the wafer afloat as it travels along the channel, the presence of the recesses and/or protrusions on or within the base create physical irregularities in the conduit. As a result, additional water or other fluid is required within the channel to keep the wafer floating above the highest area of the base. Accordingly, improved water tracks with fewer recesses and/or protrusions are desired.

Each prior-art track typically includes two oppositely disposed rails to guide the wafer as it moves along the track. The rails are fixedly attached to the base of the conduit, and the spacing between the rails is generally slightly larger that the diameter of the wafer to be processed through the track. Although water tracks including fixedly attached rails may be relatively easy to manufacture and provide rigid support for the wafer as the wafer moves along the track, the fixedly attached rails do not facilitate using a single track to transport wafers of various sizes. For example, the fixed-rail track could not be used to process wafers having a diameter larger than the distance between opposing rails, and if the distance between rails is too large compared to the wafer diameter, the wafer may cause increased wear on the rails as the wafer collides with the rail during transportation. Additionally, if the distance between opposing rails is much larger than necessary, the track may be unnecessarily expensive and take up more space than necessary. Accordingly, an improved water track configured to process wafers of various sizes is desirable.

The apertures formed within the base of the track are generally formed by drilling holes through the base at an angle other than about ninety degrees with respect to a planar surface of the base. The apertures are usually formed such that water exits the aperture in a direction that is partially upward and partially in the direction of the desired wafer movement. By directing the effluent water upward and in the direction of desired wafer movement, the water jets

provide a stream of water within the conduit that flows in a predetermined direction; the upward direction of the effluent water provides support such that the wafers do not sink in the fluid stream (semiconductor wafers generally do not float in water). Forming apertures within the base that are not perpendicular to a surface of the base is arduous. In addition, a typical water track includes about 0.6 to 0.9 apertures per square inch of the base (between the rails) to provide adequate water movement in the conduit. Each aperture formed increases manufacturing costs associated with the track. Accordingly, an improved water track with water supply devices that are relatively easy and inexpensive to manufacture is desired.

In addition to the apertures formed in the base plate, side water jets may be used to assist wafer movement in a desired direction. The side jets are typically mounted on the track such that water exiting the jets hits the wafer at the edge of the wafer, and the water is generally directed towards the wafer in the direction of desired wafer movement. Although side jets may be effective in moving or urging the wafer in a desired direction, the water jets are relatively inefficient. In part, the side water jets are inefficient because the cross-sectional area of the wafer that receives the water is relatively small (the wafer is often less than about 1 mm thick). As a result, much of the water directed at the edge of the wafer is either deflected upwards or downwards or the water misses the edge of the wafer entirely. Accordingly, an improved water track with a more efficient mechanism to urge a wafer in a desired direction is desirable.

SUMMARY OF THE INVENTION

The present invention provides improved apparatus for moving or urging a workpiece in a desired direction. More particularly, the present invention provides an improved fluid track that uses less fluid to move a workpiece than conventional water tracks.

The way in which the present invention addresses the drawbacks of the now-known water or fluid tracks is described in greater detail hereinbelow. However, in general, the improved fluid track includes a channel formed by a base and guides attached to the base. The base includes apertures which are configured to discharge fluid into a channel in the direction of the workpiece to suspend the workpiece above the base of the track.

In accordance with an exemplary embodiment of the present invention, a fluid track includes a base having a substantially planar surface. In accordance with a further aspect of this embodiment the base includes apertures that have an axis that is substantially perpendicular to the planar surface. In accordance with yet a further aspect of this embodiment, the base includes about six apertures per bottom surface area of the workpiece.

In accordance with another exemplary embodiment of the present invention, a fluid

track includes water jets that direct water towards a top surface of the workpiece and in the direction of desired workpiece movement to urge the wafer in the desired direction.

In accordance with yet a further embodiment of the present invention, a fluid track is configured to transport wafers of various sizes. In accordance with this embodiment, the distance between opposing guides is adjustable.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be derived by referring to the detailed description and claims, considered in connection with the figures, wherein like reference numbers refer to similar elements throughout the figures, and:

Figure 1 illustrates, in perspective view, a chemical mechanical polishing apparatus in accordance with the present invention;

Figure 2 illustrates a cross-sectional view of the chemical mechanical polishing apparatus shown in Figure 1, including three fluid tracks;

Figure 3 illustrates, in top view, an exemplary fluid track in accordance with the present invention;

Figure 4 illustrates, in top view, a fluid track in accordance with an alternative embodiment of the present invention;

Figure 5 illustrates, in top view, a fluid track in accordance with yet another exemplary embodiment of the present invention;

Figure 6 is a perspective illustration of a fluid track having a rinse station and overhead spray assemblies attached thereto in accordance with the present invention; and

Figure 7 illustrates a top plan view of a showerhead in accordance with the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present invention generally relates to apparatus for transporting workpieces, and more particularly to a fluid track configured to move a workpiece in a desired direction. Although the present invention may be used to transport a variety of workpieces between a variety of processes or apparatus, the present invention is conveniently described below in connection with transporting semiconductor wafers between various post-chemical mechanical polishing cleaning and rinsing processes.

Figures 1 and 2 illustrate a chemical mechanical polishing machine 100 including multiple fluid tracks 200, 210, and 220 in accordance with an exemplary embodiment of the present invention. Polishing machine 100 suitably includes a wafer load and unload station

110; polishing module 120, including an indexing station 230 and a polishing station 240 having a polishing surface 250; and a cleaning station 130, including tracks 200, 210, and 220.

Machine 100 is typically employed to remove a desired amount of material from one or more surfaces of a wafer 260. As explained in more detail below, machine 100 is configured to remove dry wafers 260 from a cassette 270, polish, clean, rinse, and dry wafer 260, and return wafer 260 to cassette 270 at load and unload station 110.

In operation, one or more wafers 260 are loaded onto machine 100 at station 110. Wafers 260 are then transported to indexing station 230 using a robot 280. At indexing station 230, wafers 260 are loaded (*e.g.*, from a load cup at station 230) into polishing carriers 290, and are transported to polishing station 240 for processing. Material is removed from a surface of wafer 260 by moving the surface relative to polishing surface 250; such polishing often occurs in the presence of deionized water, a slurry composition, or a combination thereof. After wafers 260 are polished, wafers 260 are transported back to indexing station 230 (*e.g.*, to an unload cup at station 230). From indexing station 230, wafers 260 are transferred to cleaning station 130 using a flipper 300.

Exemplary cleaning station 130 includes first fluid track 200, a first scrub station 310, second fluid track 210, a second scrub station 320, third fluid track 220, a rinse station 330, and a dryer 340. First fluid track 200 receives wafer 260 from flipper 300, and urges wafer 260 into first scrub station 310. Similarly, second fluid track 210 receives wafer 260 from scrub station 310 and urges wafer 260 into second scrub station 320. Third fluid track 220 is suitably configured to urge wafer 260 to rinse station 330. After wafer 260 has been rinsed, robot 280 transports wafer 260 into dryer 340. Then, robot 280 moves wafer 260 from dryer 340 to cassette 270 at load and unload station 110.

In accordance with the present invention, fluid tracks 200, 210, and 220 are configured to transport wafer 260 from one position to another by suspending wafer 260 in fluid and applying fluid pressure to wafer 260 to urge wafer 260 in a predetermined or desired direction. Wafer 260 is suspended by providing a thin film of fluid to a bottom surface of wafer 260 to keep wafer 260 above a bottom surface of the track. As described in greater detail below, exemplary tracks 200, 210, and 220 are configured to use less fluid, to be easier and less expensive to manufacture, to allow wafers of various sizes to be moved, and to allow the wafer to move in multiple directions (*e.g.*, forward, backward, or rotationally) within the track.

The configuration of a particular fluid track may vary from application to application. However, in general, a fluid track in accordance with the present invention includes a base having apertures formed therein, through which water flows from the base towards a

workpiece, and guides to steer the workpiece or workpieces to a desired destination.

Figure 3 illustrates a top view of track 200. Track 200 includes a base 350 having apertures 360 formed therein and rails 370, 372, and 374 to assist wafer 260 movement in a desired direction, *e.g.*, the direction indicated by arrow A. Track 200 also includes fluid inducement or propelling mechanisms such as nozzles 380 to urge wafer movement in a desired direction. Similarly, as illustrated in Figures 4-6, tracks 210 and 220 suitably include bases 400 and 500, apertures 410 and 510, rails 420-430 and 520-530, and nozzles 440 and 540. Although a fluid track in accordance with the present invention may be configured in a variety of ways such as, for example, to form exemplary fluid track 200 illustrated in Figures 3, for the sake of brevity and concision, a fluid track in accordance with the present invention is described in more detail below in connection track 220, which is best illustrated in Figures 5 and 6.

Base 500 of track 220 may be formed of any material that is compatible with the fluid used to suspend wafer 260; preferably, the material is also compatible with chemicals used during polishing of wafer 260. Alternatively, base 500 may be coated with a materials that are compatible with the suspension fluid and/or chemicals used to polish wafer 260. In accordance with a preferred embodiment of the present invention, base 500 is formed of polymeric material such as polyethylene terephthalate (PET).

Base 500 suitably includes a substantially planar surface 550, over which wafers 260 traverse. More specifically, base 500 preferably does not include any substantial protrusions or recesses on surface 550. It is believed that planar surface 550 requires less fluid to suspend and transfer wafer 260 in comparison to tracks having bases with substantial protrusions or recesses. In accordance with an exemplary embodiment of the present invention, base 500 includes a width, indicated by arrow W, which is wider that the longest dimension (e.g., a diameter) of wafer 260. This allows wafer 260 to be suspended relatively close to surface 550.

Base 500 also includes fluid supply devices such as apertures 510 to supply fluid to track 220. In general, fluid is supplied to track 220 through apertures 510 to suspend wafer 260 above surface 550. However, the rate of fluid supplied to track 220 is preferably not sufficient to create a flowing stream that would cause wafer 260 to move. Rather, the fluid emanating from apertures 510 is manipulated to suspend wafer 260 above surface 550 such that wafer 260 may be moved in any desired direction. For example, a thin film of water may suitably provide enough suspension to keep wafer 260 above surface 550. In accordance with an exemplary embodiment of the present invention, about 4 liters per minute per about 26,000 cm^2 (or 0.15 cm/minute) is supplied to track 220 through apertures 510 to keep wafer 260 suspended.

Although the size and number of apertures may depend on a particular track

configuration, in accordance with a preferred embodiment of the present invention, aperture 510 is about 0.08 to about 0.12 and preferably about 0.10 mm in diameter. Further, base 500 includes about 4 to about 8 and preferably about 6 apertures per surface area of wafer. For example, track 220 configured to process 200 mm diameter wafers would have about 6 apertures per ($\Pi * r^2$) or $1.91 * 10^{-4}$ apertures per square millimeter.

In accordance with an exemplary embodiment of the present invention, guides such as rails 520 and 530 are attached to base 500. The guides are generally configured to contain fluid on surface 550, preventing the fluid from undesirably spilling over an edge *(e.g.*, edges 560 or 570) of base 500 and to guide and contain wafer 260 as it traverses over surface 550. Any suitable means for attaching rails 520 and 530 to base 500, such as mechanical or chemical attachment means, may be employed in accordance with the present invention. Alternatively, rails 520 and 530 may be integral with base 500. However, in accordance with a preferred embodiment of the present invention, rails 520 and 530 are attached to base 500 using mechanical fasteners, namely, nuts and bolts. In accordance with a further exemplary embodiment of the present invention, rails 520 and 530 and/or base 500 includes a slot through which the bolt is inserted, such that the spacing between opposing rails 520 and 530 may be adjusted to accommodate processing wafers of various sizes.

Spacing between opposing rails depends on the size and type of workpiece traversing base 500. Generally, the spacing is selected such that wafer 260 may move across surface 500, without causing undue damage to rails 520 and 530. For example, if the diameter of wafer 260 is about 150 mm, the distance between rails 520 and 530 is about 165 mm. Alternatively, if the diameter of wafer 260 is about 200 mm, the spacing between opposing rails 520 and 530 is preferably about 220 mm.

Nozzle 540, illustrated in Figures 5-6, is preferably configured to urge wafer 260 in a predetermined direction by applying force to wafer 260 in the direction of desired movement. With wafer 260 suspended above surface 550 using fluid from apertures 510, nozzles 540 may be used to guide wafer in any desired direction. To increase the efficiency of urging force of nozzle 540, effluent from nozzle 540 is preferably directed at a planar surface of wafer 260. In other words, the effluent from nozzle 540 is not directed at an edge of wafer 260. In accordance with a preferred embodiment of the present invention, effluent from nozzle 540 is directed at a top surface of wafer 260 and in the direction of desired wafer movement, such that the effluent exits nozzle 540 at an angle of about five degrees below horizontal. In addition, nozzle 540 is preferably configured to spray fluid onto the surface of wafer 260 at a leading edge of wafer 260 and nozzle 540 preferably continues to spray fluid onto the surface until

wafer 260 passes through the fluid stream. Multiple nozzles may be placed about the perimeter of track 220 and/or above or beneath surface 550. In addition, a multi-orifice nozzle such as nozzle 600, illustrated in Figure 6, may be used to urge wafer 260 in a desired direction.

In operation, fluid such as deionized water is introduced to track 220 through apertures 510. As stated above, the flow rate of fluid is such that the fluid suspends wafer 260 above surface 550. Once fluid is present on track 220, the fluid flow through apertures 510 may be extinguished, or the flow may continue at a rate sufficient to suspend wafer 260. Wafer 260 is then urged in a desired or predetermine direction by applying a stream of water to wafer 260 through nozzle 540 and/or nozzle 600. Alternatively, track 220 may be tilted in one direction or another to urge wafer 260 to move in the desired direction. Because the present invention does not use a flowing stream of water within a channel to urge wafer 260 in a desired direction, the present invention uses less water to transport wafer 260 compared to conventional water tracks, and track 220 may be used to urge wafer 260 in multiple directions. For example multiple nozzles 540 may be placed about track 220, such that the effluent from nozzles 540 are directed in different directions. The direction of wafer movement may then be controlled by turning one or more nozzles 540 on or off.

In a preferred embodiment of the present invention, track 220 additionally includes overhead spray assemblies 610 and 620. Overhead spray assemblies 610 and 620 are suitably configured to deposit fluid such as deionized water onto a surface of wafer 260. Because track 220 is configured to use less fluid than conventional tracks, overhead assemblies 610 and 620 may be advantageous because they assist in keeping wafer 260 wet until wafer 260 passes through rinse station 330.

As illustrated in Figure 6 and in accordance with an exemplary embodiment of the present invention, track 220 is attached to or forms an integral assembly with rinse station 330. Rinse station 330 preferably includes a showerhead 700, which is best illustrated in Figure 7. Showerhead 700 is configured to rinse wafer 260 prior to wafer 260 being exposed to a drying environment. Although showerhead 700 may be configured in a variety of shapes, in accordance with a preferred embodiment of the present invention, showerhead 700 includes a substantially semi-circular portion 710. Portion 710 suitably includes one or more apertures 720 formed therein that allow fluid such as deionized water to flow therethrough onto wafer 260.

Aperture 720 is preferably configured such that effluent from aperture 720 hits wafer 260 at an angle between zero and ninety degrees, and preferably at an angle of about sixty degrees with respect to a surface of wafer 260. In addition, although aperture 720 may be

directed in several different directions, in accordance with the present invention, aperture 720 is preferably directed such that effluent from aperture 720 flows generally in the direction indicated by arrow B.

During the rinse process, wafer 260 is transferred to station 330 and fluid is caused to flow through apertures 720. Wafer 260 is preferably positioned within station 330 such that effluent from nozzle 720 hits a surface of wafer 260 proximate the edge of wafer 260 that is closest showerhead 700. Thus, water hits wafer 260 at an edge closest to nozzle 720.

Although the present invention is set forth herein in the context of the appended drawing figures, it should be appreciated that the invention is not limited to the specific form shown. For example, while the inventive fluid track is described above in connection with a chemical mechanical polishing apparatus, various other apparatus such as disk polishers or other machines may include a fluid track in accordance with the present invention. In addition, the present fluid track may be used to transfer workpieces between various apparatus such as polishing machines and cleaning stations that are separate from the polishing machines. Various other modifications, variations, and enhancements in the design and arrangement of the fluid tracks as set forth herein may be made without departing from the spirit and scope of the present invention.

CLAIMS

We claim:

1. A fluid track for moving a workpiece comprising:

a base including a number of apertures and a substantially planar surface, wherein said number of apertures is formed within said planar surface and is configured to supply a fluid to said track such that the fluid suspends the workpiece above said base by applying pressure to a bottom surface of the workpiece;

a guide attached to said base, wherein said guide is configured to direct the workpiece in a desired direction; and

a workpiece propelling mechanism coupled to said guide, said mechanism configured to apply a fluid to a surface of said workpiece to urge said workpiece in a predetermined direction.

2. The fluid track according to claim 1, wherein said number of apertures is about 4 to about eight per bottom surface area of said workpiece.

3. The fluid track according to claim 1, wherein said base is formed of polyethylene terephthalate.

4. The fluid track according to claim 1, wherein said apertures are substantially cylindrically shaped and have a diameter of about 0.1 millimeters.

5. The fluid track according to claim 1, wherein said propelling mechanism includes a nozzle for distributing said fluid onto said top surface.

6. The fluid track according to claim 1, further comprising an overhead spray assembly coupled to a portion of the track, wherein said spray assembly is configured to apply a fluid onto a top surface of the workpiece.

7. The fluid track according to claim 1, further comprising a rinse station coupled to a portion of the track, wherein said rinse station is configured to apply a fluid onto a top surface of the workpiece.

8. The fluid track according to claim 7, wherein said rinse station includes a showerhead.

9. The fluid track according to claim 1, wherein a width of said substantially planar surface is at least as large as the longest dimension of a bottom surface of the workpiece.

10. An apparatus for urging a workpiece in a desired direction, said apparatus comprising:

a base including a number of apertures configured to allow a fluid to flow through said base towards a bottom surface of the workpiece, wherein the workpiece is suspended by the fluid above a surface of said base and said number of apertures is less than about eight per said bottom surface area of the workpiece;

a rail attached to said base, wherein said rail is configured to guide the workpiece as the workpiece moves in the desired direction; and

a nozzle attached to said rail, wherein said nozzle is configured to assist movement of the workpiece in the desired direction by discharging the fluid onto a surface of the workpiece.

11. The apparatus according to claim 10, wherein the fluid is deionized water.

12. The apparatus according to claim 10, wherein said apertures have a diameter of about 0.1 millimeters.

13. The apparatus according to claim 10, wherein said base is formed of polyethylene terephthalate.

14. The apparatus according to claim 10 further comprising a rinse station coupled to a portion of the apparatus, wherein said rinse station is configured to assist removal of debris from a surface of the workpiece.

15. The apparatus according to claim 14, wherein said rinse station includes a showerhead.

16. The apparatus according to claim 10, further comprising an overhead spray assembly, wherein said assembly is configured to apply fluid to the workpiece.

17. The apparatus according to claim 10, wherein the fluid flows at a rate of about 0.15 cm per minute.

18. The apparatus according to claim 10, wherein said nozzle is configured to direct the fluid at a top surface of the workpiece.

19. The apparatus according to claim 10, wherein said apertures are formed within a substantially planar surface of said base.

20. An apparatus for urging a workpiece in a desired direction, said apparatus comprising:

a base configured to receive the workpiece, wherein said base includes apertures configured to allow a fluid to flow onto a surface of said base; and

an adjustable guide attached to said base, said adjustable guide configured to allow processing of workpieces of various sizes and to guide the workpieces as the workpieces move across a portion of said surface of said base.

21. The apparatus according to claim 20, further comprising a workpiece propelling mechanism configured to urge the workpiece in a desired direction.

22. The apparatus according to claim 20, further comprising a nozzle attached to said apparatus, wherein said nozzle is configured to supply a fluid that applies a force to a top surface of said workpiece.

23. The apparatus according to claim 20, wherein said base includes a substantially planar surface.

24. A fluid track configured to move a workpiece, the track comprising:

a base having a film of fluid interposed between the workpiece and said base, wherein said film suspends the workpiece above said base; and

a workpiece propelling mechanism coupled to said base, said mechanism configured to apply a fluid to a top surface of said workpiece to urge said workpiece in a predetermined direction.

25. The fluid track according to claim 24, further comprising a guide to encourage workpiece movement in a desired direction.

26. The fluid track according to claim 24, wherein said base includes a substantially planar surface configured to receive the workpiece.

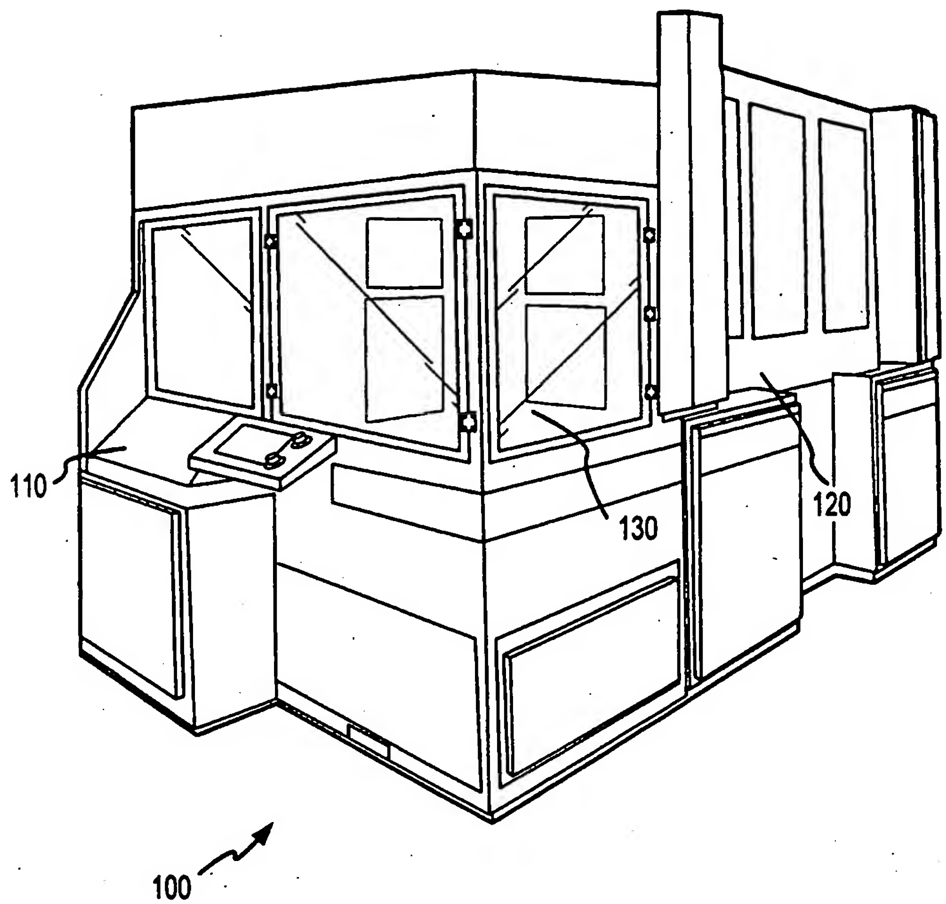

FIG.1

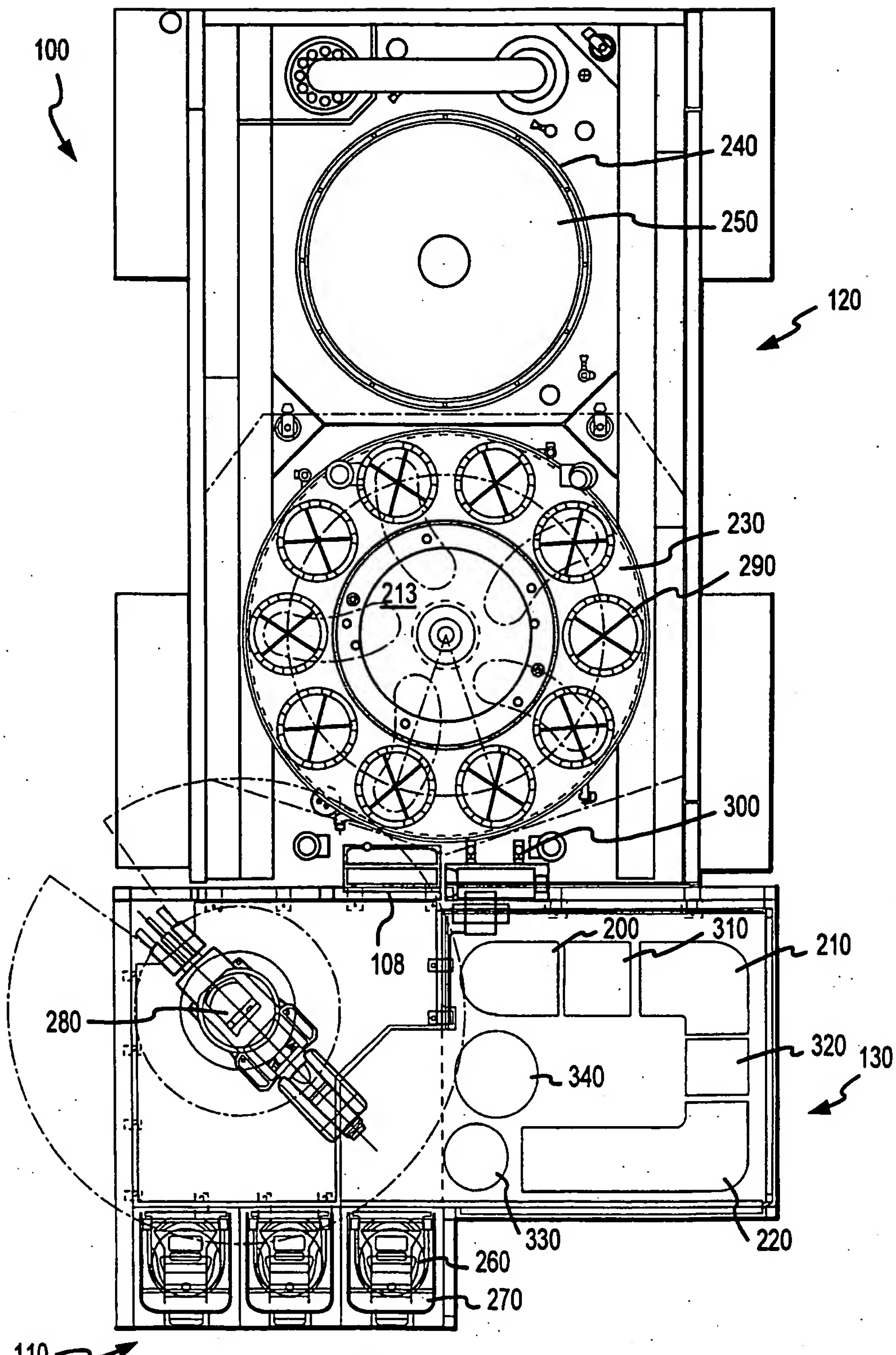
100
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FIG.2

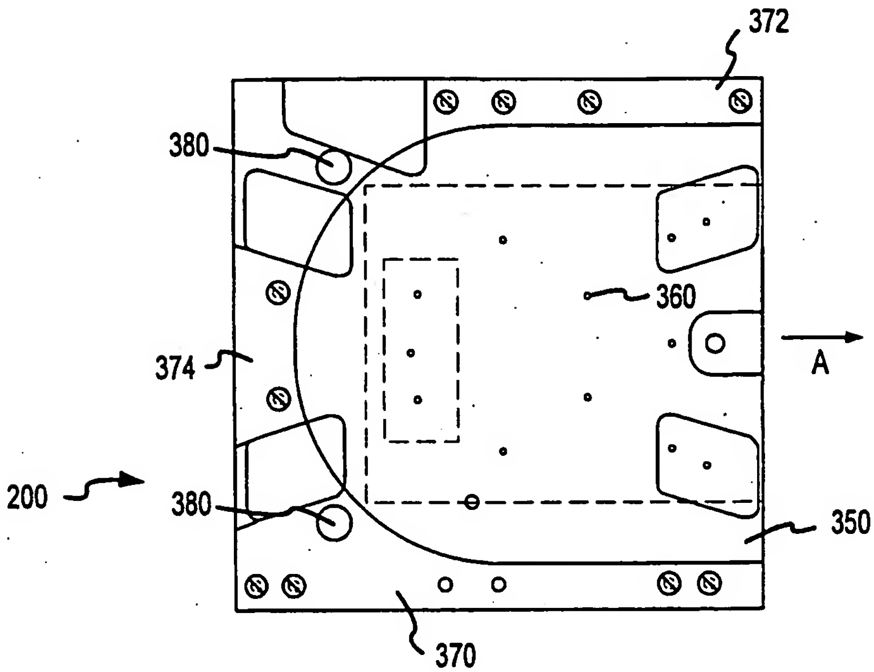

FIG.3

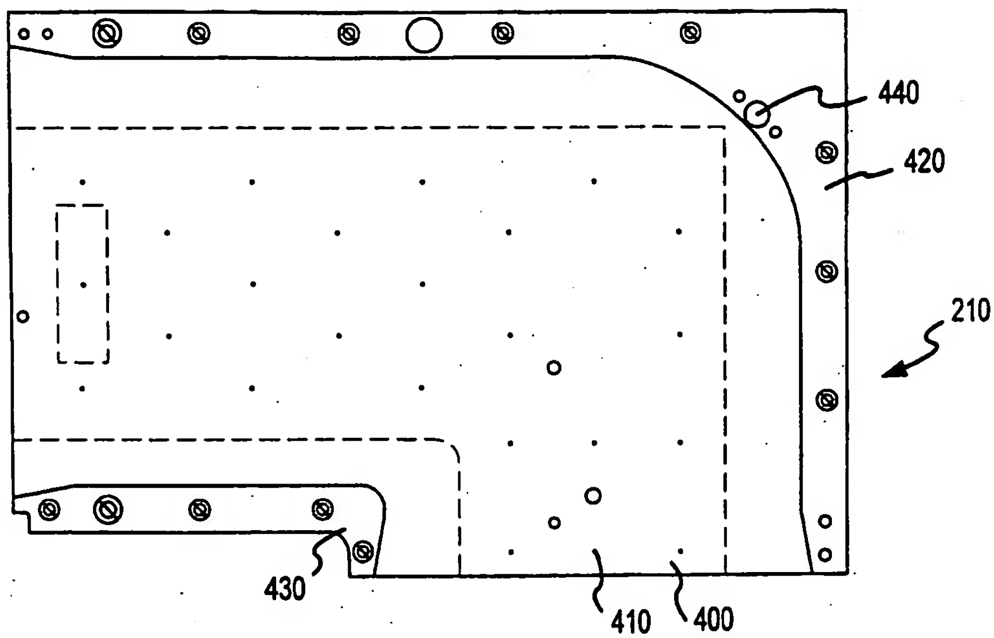

FIG.4

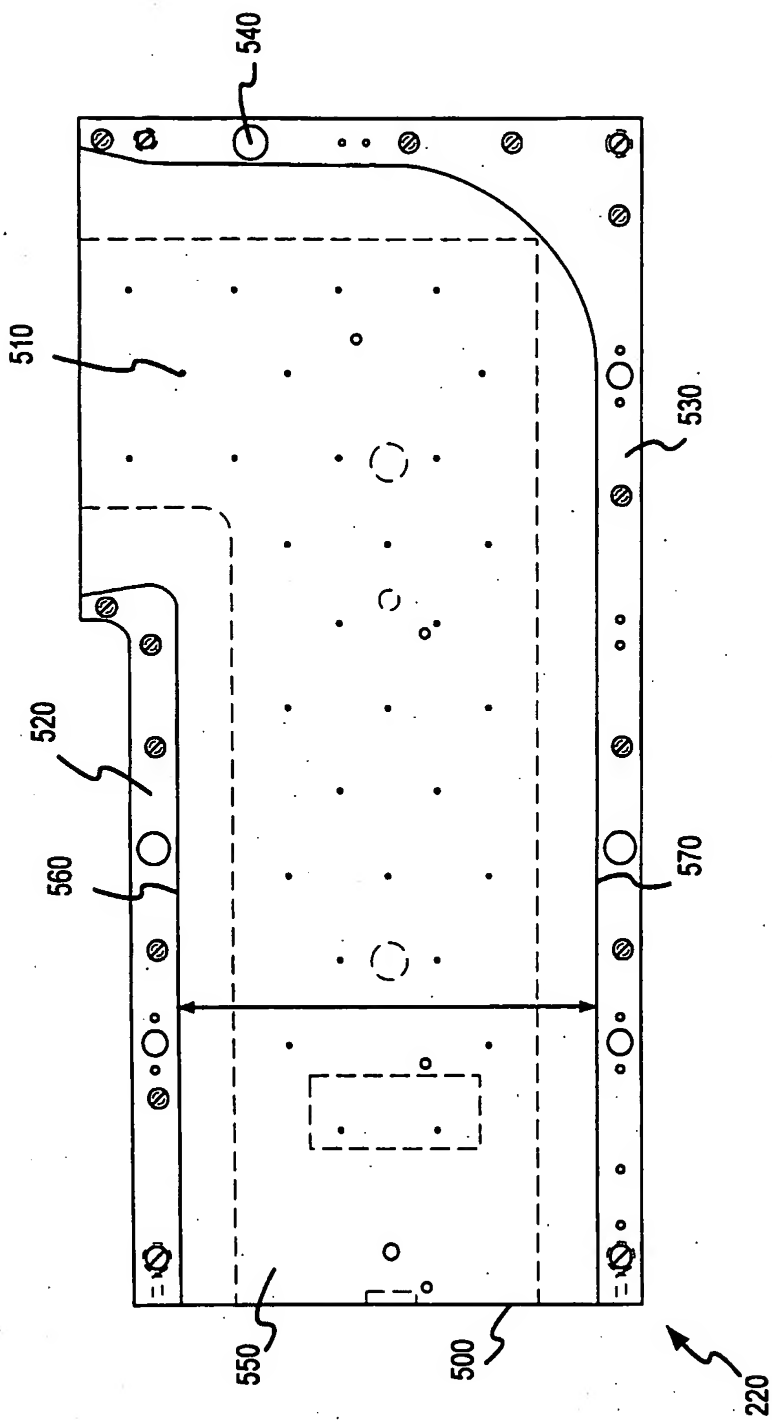

FIG.5

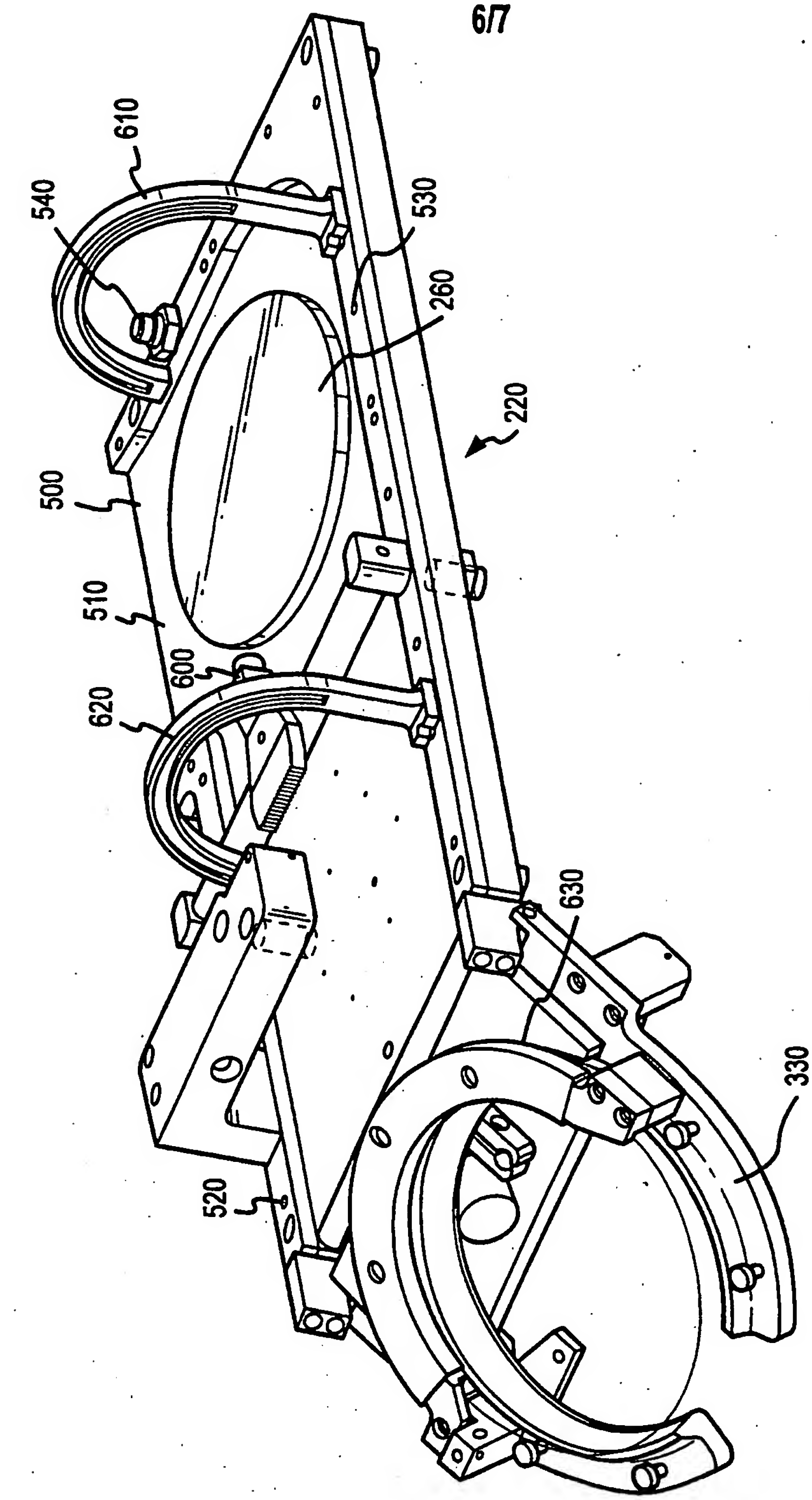

FIG.6

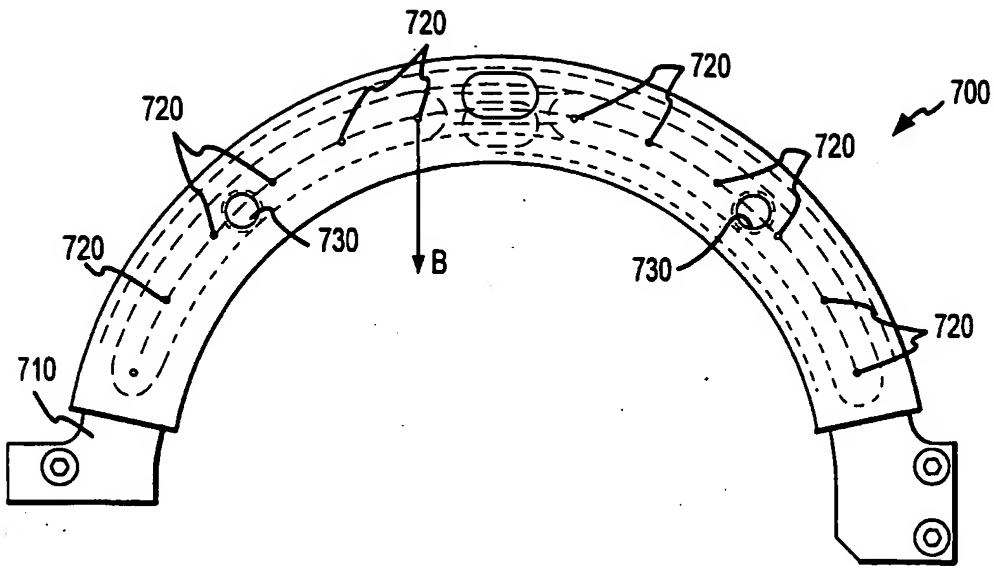

FIG.7